REPORT DOCUMENTATION PAGE

AFRL-SR-AR-TR-05-
0480

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
		Final Report

4. TITLE AND SUBTITLE
Theory and Alogorithms for Global/Local Design Opimization

5. FUNDING NUMBERS
F49620-02-1-0090

6. AUTHOR(S)
Dr. Watson

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
AFOSR

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION AVAILABILITY STATEMENT

NM

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The motivating application for this research is the global/local optimal design of composite aircraft structures such as wings and fuselages, but the theory and algorithms are more widely applicable in engineering design. Research is proposed on three distinct topics. (1) Rigorous mathematical theory will be developed supporting a decomposition strategy for global/local optimization. Advanced computational and numerical approximation techniques, such as massively parallel computing and surrogate functions, will be used in the decomposition. (2) Local panel optimization algorithms that can handle both discrete and continuous variables efficiently will be investigated. Several different strategies for blending local composite panel designs to improve manufacture will be developed and tested. (3) Mathematical theory and parallel computing paradigms for cellular automata applied to structural design will be developed and validated on a variety of structural design problems. Comparison to standard FEM-based optimization will be done.

14. SUBJECT TERMS			15. NUMBER OF PAGES
			16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT

FINAL REPORT FOR AFOSR GRANT F49620-02-1-0090

THEORY AND ALGORITHMS FOR GLOBAL/LOCAL DESIGN OPTIMIZATION

Period: 01/01/2002 — 09/30/2005

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Objectives.

The motivating application for this research is the global/local optimal design of composite aircraft structures such as wings and fuselages, but the theory and algorithms are more widely applicable in engineering design. Research is proposed on three distinct topics. (1) Rigorous mathematical theory will be developed supporting a decomposition strategy for global/local optimization. Advanced computational and numerical approximation techniques, such as massively parallel computing and surrogate functions, will be used in the decomposition. (2) Local panel optimization algorithms that can handle both discrete and continuous variables efficiently will be investigated. Several different strategies for blending local composite panel designs to improve manufacture will be developed and tested. (3) Mathematical theory and parallel computing paradigms for cellular automata applied to structural design will be developed and validated on a variety of structural design problems. Comparison to standard FEM-based optimization will be done.

Major accomplishments.

Significant progress was made on each of the three research objectives. (1) Haftka and Watson developed a rigorous decomposition theory for a large class of multidisciplinary design optimization problems involving both real and integer variables, and demonstrated the utility of the theory for parallel optimization and large scale engineering design. (2) Significant new genetic algorithms employing memory, migration, new mixed integer variable encodings, and new local improvement schemes were developed and applied to blended composite panel wing design. (3) The suitability of cellular automata for massively parallel structural design was explored in depth, with both theoretical and applied results obtained.

The project produced two Ph.D. theses, two M.S. theses, and partially supported numerous students and visiting faculty besides the PIs. Directly or indirectly attributable to the grant support are over 45 journal publications, over 60 refereed conference papers, and over 20 articles currently under review. Substantial technology transition to industry and government also occurred during the grant period.

Personnel supported.

Faculty supported by the grant are Z. Gürdal, R. T. Haftka, and L. T. Watson. Graduate students supported by the grant are David Adams and Vladimir Gantovnik at Virginia Tech, and Laurent Grosset and Jaco Schutte at Florida. Others associated with the project are students Shahriar Setoodeh, Omprakash Seresta, Ozlem Armutcuoglu, Mostafa Abdalla, Douglas Slotta, and Manjula Iyer, post-docs Boyang Liu and Samy Missoum, and a Statistics Department faculty member Christine Anderson-Cook.

Publications.

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S. Hosder, B. Grossman, R. T. Haftka, W. H. Mason, and L. T. Watson, "Quantitative relative comparison of CFD simulation uncertainties for a transonic diffuser problem", *Comput. & Fluids*, to appear.

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A. Verstak, N. Ramakrishnan, K. K. Bae, W. H. Tranter, L. T. Watson, J. He, C. A. Shaffer, and T. S. Rappaport, "Using hierarchical data mining to characterize performance of wireless system configurations", *ACM Trans. Modeling Comput. Simulation.*

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Interactions/transitions.

Conference presentations were:

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International Parallel and Distributed Processing Symposium 2002, Fort Lauderdale, FL, April, 2002 (2 papers).

High Performance Computing Symposium 2002, San Diego, CA, April, 2002 (2 papers).

AIAA/ASME/ASCE/AHS/ASC 43rd Structures, Structural Dynamics, and Materials Conference, Denver, CO, April, 2002 (7 papers).

SIAM Conference on Optimization, Toronto, Canada, May, 2002 (3 papers).

IEEE 2002 Radio and Wireless Conference, Boston, MA, August, 2002.

Electronic Prototyping Review Meeting, Sunnyvale, CA, July, 2002.

9th AIAA/ISSMO Symp. on Multidisciplinary Analysis and Optimization, Atlanta, GA, Sept., 2002 (7 papers).

IEEE Vehicular Technology Fall Conference, Vancouver, Canada, Sept., 2002.

Sixth European Panel Products Symposium, Llandudno, Wales, United Kingdom, Oct., 2002.

International Academy of Wood Science Annual Meeting, Beijing, China, Oct., 2002.

OSB World Symposium and Exposition, Chicago, IL, Oct., 2002.

3rd International Conference on Systems Biology, Stockholm, Sweden, Dec., 2002.

SIAM Conference on Computational Science and Engineering, San Diego, CA, Feb., 2003.

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AIAA/ASME/ASCE/AHS 44th Structures, Structural Dynamics, and Materials Conf., Norfolk, VA, April, 2003 (6 papers).

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Summer Bioengineering Conference, Key Biscayne, Florida, June 2003 (2 papers).

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American Soc. for Composites 18th Technical Conf., Gainesville, FL, October, 2003.

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International Parallel and Distributed Processing Symposium 2004, Santa Fe, NM, April, 2004.

Numerical Aspects of Circuit and Device Modeling Workshop, Santa Fe, NM, June, 2004.

Forest Products Society 58th Annual Meeting, Grand Rapids, MI, June, 2004.

AFOSR Workshop and Contractors' Meeting, Pasadena, CA, August, 2004.

10th AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference, Albany, NY, August, 2004 (6 papers).

26th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, San Francisco, CA, Sept., 2004.

SPIE 11th Annual International Symposium on Smart Structures and Materials: Modeling, Signal Processing, and Control, San Diego, CA, 2004.

Spring Simulation Multiconference, San Diego, CA, April, 2005 (3 papers).

SIAM Annual Meeting, New Orleans, LA, July, 2005.

International Conference on Complementarity, Duality, and Global Optimization in Science and Engineering, Blacksburg, VA, August, 2005.

American Society for Photogrammetry and Remote Sensing 16th Pecora Symposium, Sioux Falls, SD, Oct., 2005.

Technology transitions or transfer:

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RESULT
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Linkage mechanism design; combustion chemistry; robotics; CAD/CAM

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APPLICATION
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RESULT
Adaptive GMRES algorithm; mathematical software
APPLICATION
Iterative solution of large linear systems arising from tire modelling

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RESULT
Probability based genetic algorithms
APPLICATION
Design of composite automotive structures

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RESULT
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APPLICATION
Design of aircraft

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RESULT
Genetic algorithms for composite laminate design
APPLICATION
Design of helicopter frame structures for minimum weight and cost

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RESULT
Blending algorithm for multipanel composite structural design
APPLICATION
Design of helicopter skin structures for minimum weight and cost

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RESULT
Displacement based optimization for structures with nonlinear response
APPLICATION
Minimum weight design of automotive structures for crashworthiness